Russian Scholarship Project
open doors
Association "Global Universities"

Program: Chemistry

General and inorganic chemistry

Main types of chemical bonds. Representation of orbital hybridization. Geometry of polyatomic molecules.

Acid-base balance. Solutions of strong electrolytes. Protolytic equilibrium in aqueous solutions of weak acids and bases. Buffer solutions.

Heterogeneous equilibria in the system of solid state – solution for insoluble electrolyte.

Redox equation. Standard, real, and formal redox potentials. The direction and depth of the redox reaction.

Chemistry of coordination compounds. Structure and isomerism of coordination compounds. Equilibria in solutions of coordination compounds.

Chemistry of elements. Typical valences, degrees of oxidation, compounds formed, their physical and chemical properties, application in industry and national economy.

Analytical chemistry

The main metrological characteristics of the analysis. Statistical processing and presentation of analysis results.

The most common types of titration: acid-base, redox, precipitation, complexometric titration. Indicators in titrimetric analysis.

Precipitation as the separation method. Molar solubility, solubility product. The effect on the solubility of various factors. Gravimetric analysis. Gravimetric factor, calculations in gravimetry.

Extraction as a separation method. Quantitative characteristics of extraction equilibria. Types of extraction systems.

Chromatography as a method of separation, identification and quantitative determination.

Spectral analysis methods. Methods of molecular spectral analysis. Photometric analysis. Infrared spectroscopy.

Methods of electrochemical analysis. Ionometry. Potentiometric titration methods. Voltammetry. Amperometric titration.

Physical chemistry

Chemical thermodynamics. The first law of thermodynamics and its application. Internal energy, enthalpy. Heat capacity. Internal energy of a system. Heat and work. Equilibrium and non-equilibrium processes. Thermochemistry. Hess law, Kirchhoff equation. Spontaneous and non-spontaneous processes. The second law of thermodynamics. Entropy. Thermodynamic potentials and characteristic functions. Gibbs fundamental equation. Gibbs-Helmholtz equations. Criteria for the direction of spontaneous processes in isolated and closed systems. The third law of thermodynamics (Nernst theorem), Planck postulate. Chemical potential. Chemical equilibria. The law of mass action and the equilibrium constant. Isotherm equation, isobaric and isochoric processes of chemical reaction. Phase equilibria. Heterogeneous systems. Gibbs'phase rule. Clausius-Clapeyron relation. Phase diagrams. Properties of solutions.

Electrochemistry. Thermodynamics of electrochemical systems. Electrochemical potential and equilibrium conditions. EMF of an electrochemical cell, electrode potential. Nernst equation. The electrical conductivity of electrolyte solutions. Ion mobility and transport numbers. Debye – Hückel theory.

Surface phenomena. Thermodynamics of surface phenomena. Adsorption. Gibbs and Langmuir's isotherm adsorption.

Chemical kinetics and catalysis. Phenomenological kinetics. The effect of temperature on the reaction rate. Arrhenius equation, activation energy, methods of its determination.

Fundamentals of statistical thermodynamics, the structure of matter and quantum chemistry.

Organic chemistry

Description of the structure of organic molecules: the nature of the chemical bond, distribution of electron density in a molecule due to various electronic effects of its substituents, geometric features of the molecule of organic matter, including all types of isomerism.

Description of the main classes of organic compounds - alkanes and cycloalkanes, alkenes, dienes, alkynes, aromatic hydrocarbons, halogen derivatives, alcohols, carbonyl compounds, carboxylic acids, nitro compounds, heterocyclic aromatic compounds, and heterofunctional compounds - hydroxycarbonyl, including carbohydrates, hydroxy and amino acids and others.

The main methods of synthesis of all mentioned classes of compounds and their chemical transformations.

The mechanisms of all studied reactions taking into account the electronic and spatial structure of reagents and substrates.

Natural sources of organic compounds, main methods of synthesis of key substances, the transformation of these compounds into others, including both laboratory and industrial methods.

The main ways of using organic compounds for the needs of humankind.

Basics of the interaction of organic substances with living organisms, including the environmental aspects of organic chemical production.

Basics of molecular spectroscopy (IR, UV, NMR), as well as mass spectrometry and X-ray diffraction.

Bioorganic chemistry and biochemistry

Structure, chemical and biological properties of proteins, nucleic acids, carbohydrates, glycoconjugates, and lipids.

Chemical synthesis of peptides, polypeptides. Chemical synthesis of nucleic acids and their components. Determining the sequence of amino acids in peptides and proteins: protein sequencing. DNA and RNA sequencing. Chemical and posttranslational modification of proteins and nucleic acids.

Physico-chemical methods for the isolation and study of biopolymers and biologically active compounds.

Enzymes: structure, classification and mechanism of enzymatic action. Kinetics of enzymatic reactions, inhibition. Major bioenergetic processes: oxidation of carbohydrates, fatty acids; citric acid cycle, electron transport chain, gluconeogenesis, ketosis. Biosynthesis of proteins, carbohydrates, lipids, nucleic acids and their components. Regulation of biochemical processes.

Literature

1. Housecroft C.E., Constable E.C. Chemistry. 4th edition. — Pearson, 2010. — 1553 p.
2. Shriver D.F, Atkins P.W. Inorganic Chemistry. 5th ed. - W.H. Freeman and Co., NY, 2010. - 824 p.
3. N.N. Greenwood and A. Earnshaw. Chemistry of the elements. Butterworth-Heinemann, 1997.
4. David Harvey. Modern Analytical Chemistry. The McGraw-Hill, 2000.
5. Gary D. Christian. Analytical Chemistry. Wiley, 2003.
6. P. W. Atkins, Julio De Paula. Physical Chemistry, Oxford University Press, 2006
7. Thomas Engel, Philip Reid. Physical Chemistry, Pearson Education Limited, 2014
8. Boyd, Morrison. "Organic Chemistry", Prentice-Hall.
9. Clayden, Greeves, Warren "Organic Chemistry", Oxford University Press, 2000.
10. Smith M.B., March J. "March's Advanced Organic Chemistry", 6th ed. - Wiley-Interscience, 2007.
11. Carey F.A. Advanced organic chemistry. 5th ed., MGH, 2004
12. Ternay A.L. Contemporary organic chemistry. Second edition. University of Texas, Arlington. 1979.
13. Roberts J.D., Caserio M.C.. Basic principles of organic chemistry. California Institute Technology. W.A. Benjamin, Inc., 1964, New York – Amsterdam.
14. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, 4-6th Edition.
15. Hermann Dugas, Bioorganic Chemistry: A Chemical Approach to Enzyme Action (Springer Advanced Texts in Chemistry), 3rd Edition, 1996.
16. David Van Vranken, Gregory A. Weiss, Introduction to Bioorganic Chemistry and Chemical Biology, 1st Edition, 2013.